The Trend of Malaria in 2011-2013 and its Relationship to Age, Gender, and Season in Kodi Utara Subdistrict, Sumba Barat Daya

I Gusti N.A.A. Oktafandi,[1] Saleha Sungkar[2]

Medical Science Program, Faculty of Medicine Universitas Indonesia
Department of Parasitology, Faculty of Medicine Universitas Indonesia

Abstract

Malaria is a public health problem in Indonesia, especially in East Nusa Tenggara. Factors, such as age, gender, and season, are considered to be related with malaria. The objective of this study is to know the trend and proportion of malaria in 2011-2013 and its relationship with age, gender, and season in Kodi Utara Subdistrict, Sumba Barat Daya (SBD). The design of this study is cross-sectional and using secondary data which is obtained from Kodi Utara Primary Health Care Center on June 25th 2014. The data is all recorded data of patients who came to Kodi Utara Primary Health Care Center and underwent diagnostic test for malaria in 2011-2013. As a result, it is found that the trend of malaria in 2011-2013 is unstable, but it shows that the highest average number is found in 2011 (170.3 people) and the lowest one is found in 2013 (103.3 people). It is also found that there is a significant difference between the proportion of malaria with age, gender, and season ($p<0.05$). The conclusion is that the number of malaria patients decrease from 2011 to 2013 and there is a relationship between the proportion of malaria and age, gender, and season.
Keywords: *malaria, trend, proportion, age, gender, season, Kodi Utara, Sumba Barat Daya*

Trend Malaria pada Tahun 2011-2013 dan Kaitannya dengan Umur, Jenis Kelamin, dan Musim di Kecamatan Kodi Utara, Sumba Barat Daya

Abstrak

Malaria merupakan masalah kesehatan di Indonesia khususnya di Nusa Tenggara Timur. Faktor-faktor seperti umur, jenis kelamin, dan musim dianggap berkaitan dengan malaria. Tujuan penelitian ini adalah mengetahui trend dan proporsi malaria tahun 2011-2013 serta kaitannya dengan umur, jenis kelamin, dan musim di Kecamatan Kodi Utara, Kabupaten Sumba Barat Daya (SBD), Nusa Tenggara Timur. Desain penelitian adalah potong lintang menggunakan data sekunder yang diperoleh dari Pusat Kesehatan Masyarakat (Puskesmas) Kodi Utara pada tanggal 25 Juni 2014 berupa data pasien yang berobat ke Puskesmas Kodi Utara dan didiagnosis malaria pada tahun 2011-2013. Hasilnya didapatkan bahwa trend malaria pada tahun 2011-2013 tidak stabil, namun didapatkan angka rata-rata tertinggi pada tahun 2011 (170,3 orang) dan terendah pada tahun 2013 (103,3 orang). Terdapat perbedaan bermakna antara proporsi malaria dengan usia, jenis kelamin, dan musim ($p<0,05$). Disimpulkan bahwa angka rata-rata penderita malaria menurun dari tahun 2011 sampai 2013 dan terdapat hubungan proporsi malaria dengan usia, jenis kelamin, dan musim.
Kata kunci*: malaria, trend, proporsi, usia, jenis kelamin, musim, Kodi Utara, Sumba Barat Daya*

Introduction

Malaria is a public health problem especially in eastern part of Indonesia, i.e. Papua, East Nusa Tenggara, West Papua, Central Sulawesi, and Maluku.[1] In East Nusa Tenggara, the West Sumba District particularly, malaria was ranked first among the 10 major public health problems and is responsible for the majority of child mortality in the area. The malaria parasites are predominately *Plasmodium falciparum* and *P.vivax*.[2] In 2011 *annual parasite index*/API was 71.83‰ and 30.38‰.

Malaria has a wide variety of symptoms. Commonly, it consists of high fever, chills, sweats, headaches, nausea, vomiting, body aches, and general malaise.[3] However, sometimes these symptoms manifest as a flu-like symptoms which decreasing the awareness of the patient to malaria. In the severe stage, malaria can cause several organ failures or blood and metabolism abnormalities, such as cerebral malaria, severe anemia, hemoglobinuria, acute kidney failure, etc. Thus, preventive action against malaria and early detection and treatment is very important.

Until now, the policy of malaria control program from government consists of confirmation of clinical diagnosis by microscopic examination or rapid diagnostic test, artemisinin based combination therapy, prevention from mosquito bites, indoor residual spraying, longlasting insecticide bednet, chemoprophylaxis, intersectoral collaboration and community participation.[1] However, despite several efforts by local and national authorities to control malaria incidence, malaria remains one of the major diseases causing death in the area. Thus, a more sustainable control program has to be established.

Malaria is transmitted by mosquito bite, namely *Anopheles*.[3,4] The existence of *Anopheles* is related to the presence of water as a medium for breeding and demographical characteristics of a population such as age and gender. In 2009, malaria prevalence in West Sumba had been found to vary between 6.83% during the wet season and 4.95% during the dry season.[5] Moreover, more than one half of the positive samples were from the age group of less than 10 years old. In an attempt to establish a sustainable control program, we will conduct a survey to obtain the trend of malaria in the last three years (2011, 2012, and 2013) and its relationship to age, gender, and season. The chosen area is Kabupaten (district) Sumba Barat Daya, which is an expansion area of Kabupaten Sumba Barat in Nusa Tenggara Timur province.[6] Kabupaten Sumba Barat Daya has 11 subdistrict and Kodi Utara is the one that has the highest number of malaria patient. In 2013, the number of malaria patient in Kodi Utara Subdistrict is 1929 (4%) from 47.430 people.[6] Based on that information, Kodi Utara Subdistrict is chosen to be analyzed in this research.

Methods

The design for this study was serial cross-sectional. The data was taken in June 25th, 2014 in Kodi Utara Primary Health Care Center, SBD. The whole study was conducted for 8 months. This research was using secondary data from Kodi Utara Primary Health Care Center's records. The target population was all malaria patients in Sumba Barat Daya and the accessible population was all patients who underwent malaria diagnostic test in Kodi Utara Subdistrict. The sample of this study was same with the accessible population because although the minimum sample needed was 96 subjects, we decided to include all recorded data to obtain the trend of malaria in each year. Inclusion criteria in this study was all recorded data of patients who underwent malaria diagnostic test in Kodi Utara Primary Health Care Center in 2011-2013 and the exclusion criteria were any incomplete data of malaria patients and any data that were recorded before 2011 and after 2013.

Proportion was defined as the number of malaria cases considered in comparative relation to the whole collected data from Kodi Utara Primary Health Care Center. Age group was defined as group of age, that in this study was divided into 3 groups, which are <5, 5-18, and >18 years old. The age groups followed some previous studies based on different vulnerability and immunologic reaction between each age group towards malaria infection. Dry season was defined as a yearly period of low rainfall in Kodi Utara Subdistrict which happens from June until September. Rainy season was defined as a yearly period of high rainfall in Kodi Utara Subdistrict which happens from December until March. Transition period was defined as a yearly period of transition between dry-rainy season and rainy-dry season which happens in April-May and October-November. The dependent variable was the proportion of malaria in Kodi Utara Subdistrict in 2011-2013, while the independent variables were patient's age, gender, and season.

All data of patients who underwent malaria diagnostic test in Kodi Utara Primary Health Care Center in 2011-2013 was recorded and processed using SPSS for Windows 20th version. The data

was divided into three age groups (<5, 5-18, and >18 years old) and two gender groups (male and female). Time of admission was divided into four season groups (rainy, transition rainy-dry, dry, and transition dry-rainy). *Chi-square* test was used to know the relationship between the proportion of malaria and age, gender, and season.

To conduct this study, research proposal was submitted. Approval and permission to conduct this research were requested to Research Module FKUI. After the research proposal was approved, permission for conducting this research was given by the head of local health service of SBD and Kodi Utara Subdistrict. Data that had been taken was kept confidentially.

Results

The trend of malaria in 2011-2013 is shown in Figure 1. The trend of malaria is quite varied throughout the year of 2011, 2012, and 2013.

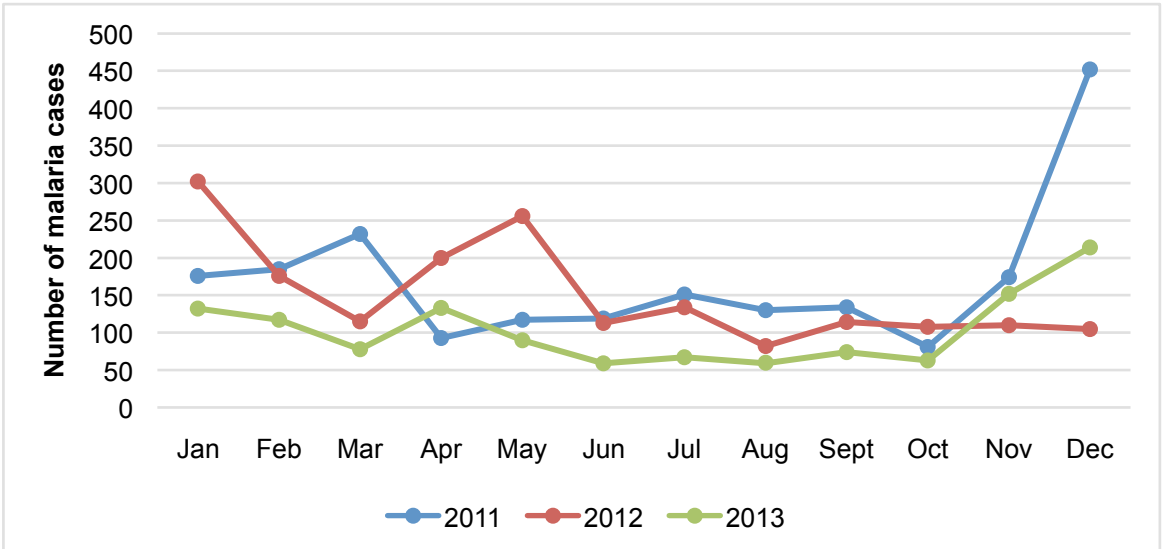

Figure 1. Trend of Malaria in Kodi Utara, 2011-2013

The highest point is shown in December 2011 with 452 malaria cases. Meanwhile, the lowest point is figured in June 2013 with 59 malaria cases. Similar to 2011, the highest number of malaria cases in 2013 is also found in December, whereas the peak point in 2012 is shown in January.

Although there are variations in the trend, if the average of malaria cases in each year is calculated, a pattern can be found with 170.3 malaria cases in 2011, 151.3 in 2012, and 103.3 in 2013. However, if the proportion that is calculated, a different pattern is found with 55.5% in 2011, 67.5% in 2012, and 65.5% in 2013.

The relationship between proportion of malaria and age groups is presented in Table 1. It is found that there are significant differences of proportion of malaria in between age groups in all three years (p≤0.001).

Table 1. Relationship between Proportion of Malaria and Age Across Years

Years	Number of Malaria Cases				
	<5 years old	5-18 years old	>18 years old	Total	p value
2011	755 (55.3%)	705 (63.5%)	584 (48.4%)	2044 (55.5%)	≤0.001
2012	622 (69.3%)	751 (74.9%)	442 (56%)	1815 (67.5%)	≤0.001
2013	348 (66.9%)	588 (72.7%)	303 (53.9%)	1239 (65.5%)	≤0.001

The relationship between proportion of malaria and gender is shown in Table 2. Significant differences of proportion of malaria between males and females are found in all three years.

Table 2. Relationship between Proportion of Malaria and Gender

Years	Number of Malaria Cases			
	Male	Female	Total	p value
2011	954 (58%)	1090 (53.5%)	2044 (55.5%)	0.008
2012	924 (73.4%)	891 (62.3%)	1815 (67.5%)	≤0.001
2013	587 (68.4%)	652 (63.1%)	1239 (65.5%)	0.017

The relationship between proportion of malaria and season is shown in Table 3. It is found that there are significant differences of proportion of malaria between seasons in all three years.

Table 3. Relationship between Proportion of Malaria and Season

Year	Number of Malaria Cases					
	Rainy	Transition rainy-dry	Dry	Transition dry-rainy	Total	p value
2011	1045 (58.3%)	210 (48.3%)	534 (51.4%)	255 (61.5%)	2044 (55.5%)	≤0.001
2012	698 (71.1%)	456 (68.5%)	443 (59.9%)	218 (72.4%)	1815 (67.5%)	≤0.001
2013	541 (69.9%)	223 (60.6%)	260 (63.9%)	215 (62.9%)	1239 (65.5%)	0.007

Discussion

Malaria is one of major diseases that is still a public health problem in Indonesia, especially East Indonesia. Even though its incidence keeps decreasing from 2007 until 2013, the incidence of malaria is still high in East Nusa Tenggara with 6.8% which is the second highest among all provinces.[1]

This study found that there was a variation and unstable fluctuation in the trend of malaria during 2011, 2012, and 2013. The highest number of malaria cases was found in December 2011, January 2012, and in December 2013. Meanwhile, the lowest point was observed in October 2011, August 2012, and June 2013.

The situation when month of each year showed the highest number of malaria cases could be explained by its association with seasonal factors. This is in accordance with a study in West Sumba that found that malaria prevalence was higher during rainy season, which is from December until March, compared to malaria prevalence during dry season (June-September).[5] The lowest number of malaria cases was apparently not all during dry period. While the lowest point was in dry period in 2012 and 2013, it was found in transitional period in 2011. This result show that in order to relate the trend of malaria and seasonal factors it is insufficient to observe the number of cases for each month, but by looking at the total number of cases during a season period which will be explained in another section in this discussion.[7-9]

Besides observing the trend of malaria for each month, the sum of malaria cases for each year was also examined. This study found that the number of malaria cases is declining in each year from 2011 to 2013. In comparison to malarial prevalence, this result is corresponding with *Riskesdas 2013*.[1] This study's might reflect the success of governmental program to eliminate malaria that started massively in 2010.[1,6] On the other hand, although the number of malaria cases decrease, the proportion showed different result with the highest proportion in 2012 and the lowest in 2011. However, in terms of observing the success rate of malaria elimination, using proportion as a standard is unreliable due to different number of people examined for malaria in each year.

This study found that there was a relationship between the proportion of malaria and age groups. This is accordant with some studies that showed a similar result that age is a major risk factor for malaria.[10-12] Gong *et al*[13] and Wipasa *et al*[14] explained that the role of age in malaria infection is determined by different immunity and vulnerability in every age stage. This result was supported by Kinyanjui[15] that found that innate and acquired immunity play a big role in determine when malaria infection will manifest in patient's body.

Although all years observed in this study showed a relationship between age and proportion of malaria, there is a varied pattern in number of cases with the highest number observed in children below 5 years old in 2011, but the highest number observed in people aged 5-18 years old in 2012 and 2013.

Some studies, including WHO, suggested that children below 5 years old is a critical age and most vulnerable age group affected by malaria.[10,11,16] WHO found that among 660.000 deaths caused by malaria in 2010, 86% of them were children below 5 years old.[10] This is also supported by a study by Roca-Feltler *et al*[16] that found more than 75% of all pediatric hospital admission caused by severe malaria were children under 5 years old. However, some studies showed a shifting in epidemiology of malaria from children below 5 years old to people over 5 years old.[17-19] Mawili-Mboumba *et al*[18] found that among 16.831 children enrolled, children older than 5 years old tend to become the most at risk of malarial infection. This is supported by Griffin *et al*[19] that found only 20% cases among 252 million malaria cases is responsible for children under 5 years old. All those studies explained that this epidemiologic changes happen due to either a decreasing level of malaria transmission in the area observed or the study was done in a low malaria transmission area from the beginning. Kleinschmidt *et al*[17] and Gong *et al*[13] explained that the severity and onset of malaria infection varies depending on the level of transmission in that area. In high transmission area, malaria cases occur more frequently and more severe in children below 5 years old; whereas in lower transmission area, the epidemiology shift to children above 5 years old. This situation occur because in high transmission area, a small number of infection in early childhood may result in acquired clinical immunity to malaria infection in adults. Kleinschmidt *et al*[17] also explained that the low number of malaria incidence in children below 5 years old in their study might be the result of a better protection offered by malaria vector control program.

This study found that there was a relationship between the proportion of malaria and gender. This is in accordance with studies by Schlagenhauf *et al*,[20] Ayele *et al*,[21] and Winskill *et al*[22] which found similar results. However, *Riskesdas* 2013[1] and WHO[23] found that vulnerability towards malaria was not related to gender. *Riskesdas* 2013[1] observed that both male and female have the same incidence.

This study found a variation in the result with more female having malaria than male in 2011 and 2013, but more male having malaria than female in 2012. Some studies explained that differences between genders in having malaria infection are not solely due to the gender factor alone, but as a result of some risk factors combination. Some studies found that exposure to *Anopheles sp.* bites is coincide with gender norm, behaviour, division of labour, leisure patterns, and sleeping arrangement.[23-25] For example, men are tend to be more at risk to malaria infection if they work in mines, field, or forest at night.[23] Ayele *et al*[21] also found that women who wake up before sunrise to perform their household activities may be more exposed to *Anopheles sp.* bites and malaria infection. Schlagenhauf *et al*[20] added that the frequency of travel is also associated with malaria infection with men travel more frequent than women, thus increase men's exposure to malaria infection. Garley *et al*[26] observed the association between the use of insecticide-treated net (ITN) and malaria infection. The result showed that males less likely to use ITN than females, thus increasing the risk of getting mosquitos bites in males.

The different proportion of malaria between male and female in this study could not be explained solely with gender as a lone risk factor. Further study regarding other risk factors, such as behaviour, division of work, leisure pattern, sleeping arrangement, frequency of travel, and use of ITN would be useful to our knowledge regarding gender disparity.

This study found that there was a significant relationship between the proportion of malaria and season. The result showed that the highest proportion of malaria occur in rainy season compared to the transition and dry period. Some studies which found a similar result, explained that this situation happen because rainfall patterns, temperature, and humidity affect the number and survival of *Anopheles sp.* thus increasing the level of malaria transmission.[27,28] Apparently, in

heavy rain, the transmission of malaria decreases because *Anopheles sp.,* as the vector of malaria, will fly away blown by the wind and their larvae will be washed away by rainwater. However, in case of light rain, puddles will be formed as proper breeding places for *Anopheles sp.* In Sumba, the climate is considered as dry even in the rainy period. Thus, in rainy season, there will be only some light rain instead of a heavy rain which supports the formation of breeding places for *Anopheles sp.* In addition, in Sumba, people often collect the rainwater for the use of their daily needs in a medium where also a suitable breeding places for *Anopheles sp*. A very similar study was also done in West Sumba by Syafruddin *et al*[5] and the result also support that there is a significant relationship between season and prevalence of malaria.

Studies by Odongo-Aginya *et al*[29] and Ardiet *et al*[30] further observed the relationship between season and malaria cases. Odongo-Aginya *et al*[29] found that not only the number of malaria cases that increase during rainy season, but also the parasite density in microscopic examination. Thus, Odongo-Aginya *et al*[29] concluded that besides number of cases, the parasite density is also an important determinant factor of malaria infection and transmission. Ardiet *et al*[30] observed further the determinants of malaria intensity and added that besides the parasite rate and density, clinical findings, such as anemia and splenomegaly, are also found more frequent in rainy period compared to dry period.

In addition, a study by Sagna *et al*[31] observed the association of malaria prevalence not only in between rainy and dry season, but also during the dry season. Sagna *et al*[31] found that the prevalence of malaria cases is higher in the beginning of dry season compared to the end of dry season. Thus, this result confirmed that the intensity of malaria infection will gradually decrease as the season goes further from rainy period.

Conclusion

This study investigated the trend of malaria in Kodi Utara Subdistrict in 2011-2013 and its relationship with age, gender, and season and found that the number of malaria cases in Kodi Utara Subdistrict decreases from 2011 to 2013. Moreover, the age, gender, and season are related to the proportion of malaria. Malaria prevention program should still emphasize on children below 5 years old as this is the critical age to get severe malaria that may lead to death, although general prevention program for every age group is also necessary. Moreover, actions regarding malaria prevention should be done more aggressively in the period of rainy season. Further observation regarding other determinants, such as behavior in relation with malaria, breeding places, and vectors density are suggested.

References

1. Badan Penelitian dan Pengembangan Kesehatan Kemenkes RI. Riset kesehatan dasar 2013 [Internet]. 2013 [cited 2014 Nov 13]. Available from: http://www.litbang.depkes.go.id/sites/download/rkd2013/Laporan_Riskesdas2013.PDF. Indonesian.
2. Barbara KA, Sukowati S, Rusmiarto S, Susapto D, Bangs MJ, Kinzer MH. Survey of *Anopheles* mosquitoes in West Sumba District, Indonesia. Southeast Asian J Trop Med Public Health. 2011;42(1):71-82. Indonesian.
3. Reksodiputro AH, Rudijanto A, Madjid A, Hermawan AG, Rachman AM, Tambunan AS, *et al*. Buku ajar ilmu penyakit dalam. 6th edition. Jakarta: Interna Publishing. 2014. p.595-608. Indonesian.
4. John DT, Jr WAP. Markell and Voge's medical parasitology. 9th edition. Philadelphia: Elsevier Health Sciences. 2013.p.79-105.
5. Syafruddin D, Krisin P, Asih B. Seasonal prevalence of malaria in West Sumba District, Indonesia. Malaria J. 2009; 8:8-15.
6. Profil Dinas Kesehatan Sumba Barat Daya tahun 2012. Tambolaka: Dinas Kesehatan Sumba Barat Daya. 2012. Indonesian.
7. MacLeod DA, Morse AP. Visualizing the uncertainty in the relationship between seasonal average climate and malaria risk. Sci Rep [Internet]. 2014 Dec 2 [cited 2015 Mar 23];4. Available from: http://www.nature.com/srep/2014/
8. Stuckey EM, Smith T, Chitnis N. Seasonally dependent relationships between indicators of malaria transmission and disease provided by mathematical model simulations. PLoSComput Biol. 2014;10(9):e1003812.
9. Alemu A, Abebe G, Tsegaye W, Golassa L. Climatic variables and malaria transmission dynamics in Jimma town, South West Ethiopia. Parasit Vectors. 2011;4(1):30.
10. WHO. Malaria in children under five [Internet]. WHO. [cited 2015 Mar 23]. Available from: http://www.who.int/malaria/areas/high_risk_groups/children/
11. Carneiro I, Roca-Feltrer A, Griffin JT, Smith L, Tanner M, Schellenberg JA, *et al*. Age-patterns of malaria vary with severity, transmission intensity and seasonality in sub-Saharan Africa: a systematic review and pooled analysis. PloS One. 2010;5(2):e8988.

12. Schwartz E, Sadetzki S, Murad H, Raveh D. Age as a risk factor for severe *P.falciparum* malaria in nonimmune patients. Clin Infect Dis. 2001;33(10):1774-7.
13. Gong L, Parikh S, Rosenthal PJ, Greenhouse B. Biochemical and immunological mechanisms by which sickle cell trait protects against malaria. Malaria Journal. 2013;12(1):317.
14. Wipasa J, Elliot S, Xu H, Good MF. Immunity to asexual blood stage malaria and vaccine approaches. Immunology and Cell Biology. 2002;80(5):401-14.
15. Kinyanjui SM. The immunology of malaria. Malaria parasites [Internet]. 2012 [cited 2015 Jan 31];1(1):175-200. Available from: http://www.intechopen.com/books/malaria-parasites/immunity-tomalaria.
16. Roca-Feltrer A, Carneiro I, Smith L, Schellenberg JR, Greenwood B, Schellenberg D. The age patterns of severe malaria syndromes in sub-Saharan Africa across a range of transmission intensities and seasonality settings. Malar J. 2010;9(1):282.
17. Kleinschmidt I, Sharp B. Patterns in age-specific malaria incidence in a population exposed to low levels of malaria transmission intensity. Trop Med Int Health TM IH. 2001;6(12):986–91.
18. Mawili-Mboumba DP, Akotet MKB, Kendjo E, Nzamba J, Medang MO, Mbina J-RM, *et al*. Increase in malaria prevalence and age of at risk population in different areas of Gabon. Malar J. 2013;12(1):3.
19. Griffin JT, Ferguson NM, Ghani AC. Estimates of the changing age-burden of *P.falciparum* malaria disease in sub-Saharan Africa. Nat Commun [Internet]. 2014 Feb 11 [cited 2015 Mar 23];5. Available from: http://www.nature.com/ncomms/2014/140211/ncomms4136/full/
20. Schlagenhauf P, Chen LH, Wilson ME, Freedman DO, Tcheng D, Schwartz E, *et al*. Sex and gender differences in travel-associated disease. Clin Infect Dis. 2010;50(6):826–32.
21. Ayele DG, Zewotir TT, Mwambi HG. Prevalence and risk factors of malaria in Ethiopia. Malar J. 2012;11(1):195.
22. Winskill P, Rowland M, Mtove G, Malima RC, Kirby MJ. Malaria risk factors in north-east Tanzania. Malar J. 2011;10(1):98.
23. WHO. Gender, health and malaria [Internet]. WHO. [cited 2015 Mar 24]. Available from: http://www.who.int/gender/documents/malaria/
24. Tin-Oo null, Pe-Thet-Htoon null, Khin-Thet-Wai null, Parks W, Bryan J. Gender, mosquitos and malaria: implications for community development programs in Laputta, Myanmar. Southeast Asian J Trop Med Public Health. 2001;32(3):588–94.
25. Esan AJ, Omisakin CT, Titilayo OE, Fasakin KA. Gender difference on stress induced by malaria parasite infection and effect of anti-malaria drug on stress index. Am J Biomed Res. 2014;2(3):42–6.
26. Garley AE, Ivanovich E, Eckert E, Negroustoueva S, Ye Y. Gender differences in the use of insecticide-treated nets after a universal free distribution campaign in Kano State, Nigeria: post-campaign survey results. Malar J. 2013;12(1):119.
27. WHO. Malaria [Internet]. WHO. [cited 2015 Mar 24]. Available from: http://www.who.int/mediacentre/factsheets/fs094/en/
28. Jawara M, Pinder M, Drakeley CJ, Nwakanma DC, Jallow E, Bogh C, *et al*. Dry season ecology of *An. gambiae* complex mosquitoes in the Gambia. Malar J. 2008;7(1):156.
29. Odongo-Aginya E, Ssegwanyi G, Kategere P, Vuzi PC. Relationship between malaria infection intensity and rainfall pattern in Entebbe Peninsula, Uganda. Afr Health Sci. 2005;5(3):238–45.
30. Ardiet D-L, Graz B, Szeless T, Mauris A, Falquet J, Doumbo OK, *et al*. Patterns of malaria indices across 3 consecutive seasons in children in a highly endemic area of West Africa. Malar J. 2014;13(1):199.
31. Sagna AB, Gaayeb L, Sarr JB, Senghor S, Poinsignon A, Boutouaba-Combe S, *et al*. *P. falciparum* infection during dry season: IgG responses to *An. gambiae* salivary gSG6-P1 peptide as sensitive biomarker for malaria risk in Northern Senegal. Malar J. 2013;12(1):301.